ESA-158-2, U. S. Steel Corporation – Fairfield, AL, Public Report

Company	U. S. Steel Corporation	**ESA Dates**	October 15-17, 2007
Plant	Fairfield Works/ Tubular Operations	**ESA Type**	Process Heating
Product	Steel products	**ESA Specialist**	Arvind Thekdi (E3M, Inc.)

Brief Narrative Summary Report for the Energy Savings Assessment:

Introduction: An Energy Savings Assessment (ESA) was carried out at U.S. Steel – Fairfield Works/ Tubular Operations located in Fairfield, AL. The plants produce various sizes of steel sheet and pipe products. This is an integrated steel mill that includes a large number of heating equipment in various parts of the plant. The equipment includes a blast furnace, BOP shop, casters, hot strip mill, pipe reheat furnace, heat treating (austenitizing and temper) furnaces, coating lines and boilers. Heating equipment in the works use a variety of energy sources such as blast furnace gas, natural gas etc.

The assessment was supported by Mr. Jason Parham of the Fairfield Works. Mr. Ken Mills, who represents U. S. Steel Best Practices, attended the assessment activities. Mr. Pawan Kumar of Prometheus Facility Resource Solutions also attended the assessment to get familiar with the assessment process and provide necessary assistance as well as technical input during the assessment. The assessment was led by the DOE process heating specialist Arvind Thekdi. Prior to the assessment Arvind Thekdi of E3M, Inc. discussed details of the assessment with Ken Mills, reviewed available data on energy use in the plant heating equipment and agreed that he would down load Process Heating Assessment and Survey Tool (PHAST) program on a computer for its use during the assessment.

Objective of the Assessment: Main objective of the assessment is to use PHAST to identify energy saving opportunities for selected heating systems in the plant, to provide hands-on training and demonstration of the data collection process, and analyze results to estimate potential savings for the identified opportunities.

Focus of assessment: The assessment was focused on process heating systems that use natural gas and other fuels such as blast furnace gas (BFG) as source of heat for process heating. The plant has large number of furnaces and boilers that use natural gas and BFG and it was not possible to conduct assessment on all of the fired equipment in the plant. The team visited following gas fired equipment and collected data for some of these furnaces energy savings opportunity analysis. Following table gives the list.

Fired Equipment – Data collection and Analysis	Fired Equipment – Observation
# 8 boiler	**Round tundish dryer**
Steel ladle heater	**Slab tundish dryer**
Austenitizing furnace – pipe mill	**Round tundish preheaters**
Tube heating furnace	**Slab tundish preheaters**
	Temper furnace in pipe mill
	Several other ladle heaters/dryers

Purchased fuel energy (natural gas) use for a selected group of heating equipment is shown in Figure 1 below. This is not a representation of all fuel energy use by the equipment because power house boilers use blast furnace gas as primary fuel and Natural gas is used for pilots, standby operation and supplementary fuel as required for the steam demand and/or power demand for the plant during certain periods in a year. Hence the following represents only a part of the total fuel energy used in the plant.

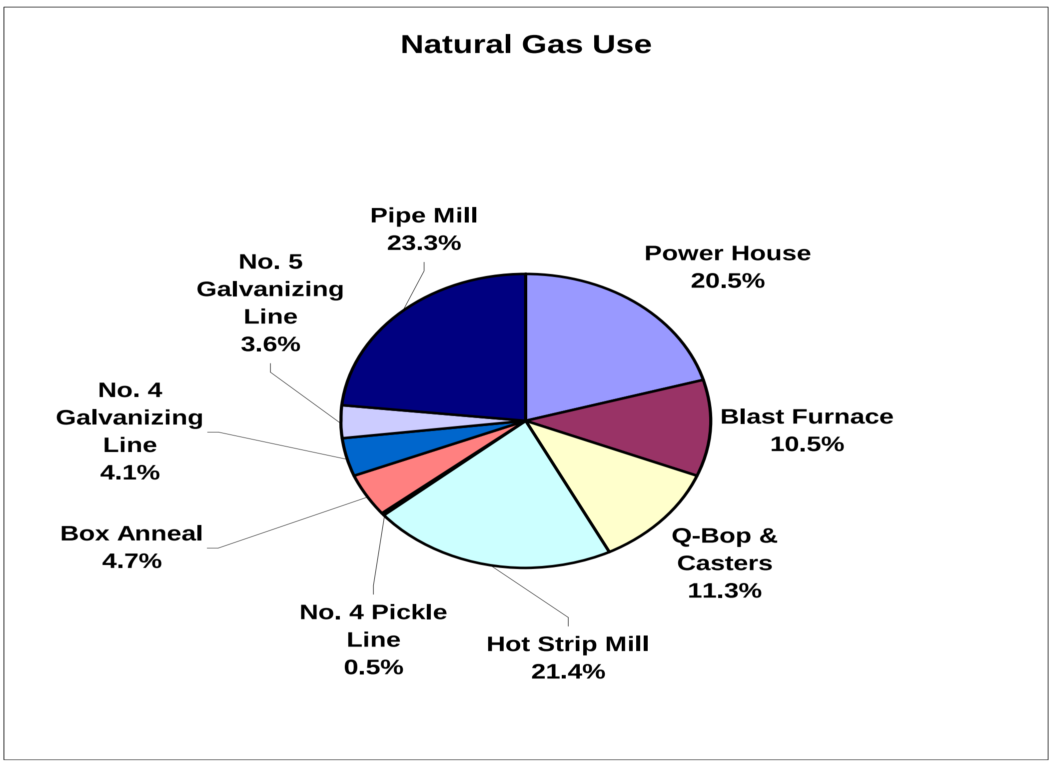

Figure 1. Natural gas usage for heating systems at U. S. Steel - Fairfield Works/ Tubular Operations

Approach for ESA: The assessment activities included (a) review of energy use by the plant, (b) plant tour, (c) brief introduction and demonstration of PHAST and instructions on its use, (d) collection of the required data for PHAST, and (e) analysis of energy saving opportunities for the systems mentioned above. The performance information was derived from historical data, control room data or actual measurements carried out by the team members. Several additional issues related to operation, maintenance and use of new technologies were discussed. The plant management was briefed on the assessment results on the third day of the assessment.

General observations. U.S. Steel is a leading corporation in steel industry with active program to achieve energy reduction plans for their plants worldwide. The plant management is becoming very active in exploring and implementing energy saving practices throughout the plant. They continuously collect and share energy saving practices with other plants. Mr. Ken Mills who heads the energy best practices application attended this assessment and provided valuable insights into USS's activities in energy efficiency improvement program activities and worked with the plant personnel as well as the assessment lead. The assessment team members provided help and cooperation in discussing and collecting performance data and demonstrated willingness to continue to use the methodology and tools demonstrated during this assessment. They are extremely interested in pursuing short and medium term energy saving opportunities. Reported values of natural gas consumption for the Fairfield Works/ Tubular Operations is in excess of 10 million MMBTU per year and other gaseous fuel consumption is in excess of 8 million MMBTU per year. Natural gas cost averages to $8.00 per MM Btu resulting in approximate annual natural gas cost of more than $80 million per year.

Potential opportunities: This plant uses a large number of heating equipment in various production areas (iron production in blast furnace, steel making in Q-BOP vessels, continuous casting of steel, hot rolling mill, cold rolling mill, annealing and galvanizing of steel sheet coils, pipe mill with its own heating equipment, number of boilers etc.) it was not possible to perform assessment for all fired equipment. During the assessment we were able to visit only selected heating equipment. They include:

- # 8 Boiler
- Steel (Pit) ladle heaters in Q-Bop shop
- Round and slab tundish dryers
- Round and slab tundish preheaters
- Tube furnace in pipe mill
- Reheat furnace in pipe mill
- Austenitizing furnace in pipe mill
- Temper furnace in pipe mill

Several observations were made for possible methods of improving performance and saving energy for each of these equipment. However we did not have enough time to collect data and perform energy savings potential analysis for each of these equipment. Hence we collected data for the following equipment and included the analysis in this report.

- # 8 Boiler
- Steel (Pit) ladle heaters in Q-Bop shop
- Tube furnace in pipe mill
- Austenitizing furnace in pipe mill

A list of observations and potential opportunities for the equipment we visited are listed below.

I. Control oxygen in flue gases in #8 boiler during during full load condition.
II. Control oxygen in flue gases in #8 boiler during stand-by (Low Fire) condition
III. Close openings for the Austenitizing furnace. Install radiation shield (door or curtain) for Austenitizing and temper furnace in pipe mill
IV. Reduce pilot natural gas use during stand-by condition for #8 boiler. If necessary use blast furnace gas to maintain boiler pressure during stand-by condition. This may require by-pass for blast furnace gas flow to #8 boiler.
V. Modify control system to allow air lead - gas follow control for #8 boiler to reduce possibility of smoke and added safety
VI. Rounds tundish preheaters – adjust fuel-air ratio to control combustion, reduce gas use and improve overall safety of the system.
VII. Install proper control of air flow and gas flow for tundish preheaters and tundish dryers. All of these systems have constant air and variable or high-low gas flow control. This results in excess air and waste of fuel.
VIII. Install proper temperature indicator control panels for tundish preheaters and slab tundish dryer.
IX. For steel ladle heaters, control air-fuel ratio to eliminate rich combustion (check air blower filters) or presence of high combustibles in flue gases.
X. Consider use of heat recovery recuperator (perhaps by preheating combustion air) for steel ladle heaters.
XI. Rebuild and use recuperator for tube furnace in pipe mill.
XII. Evaluate feasibility of use of waste heat from reheat furnaces (after the recuperators) and tube furnace for 325 psig steam generation.
XIII. Consider heat recovery from boiler blow down water for #8 boiler.

Detail data was collected for the opportunities listed in bold letters. The following discussion includes analysis results for these opportunities only.

Main areas of improvement are: reduction of excess air in flue gases, improved control of combustion conditions in tundish preheaters, preheating of combustion air by using flue gas heat in heat recuperators, improved monitoring of heating systems (tundish dryers and preheaters) by installing proper display and control instrumentation and reduction in heat losses through furnace openings. There may be additional areas of energy saving opportunities for the equipment that we did not visit. Energy saving opportunities for the equipment we visited and analyzed represent potential savings varying from $7,000 to as high as $692,000 per year for the furnaces/equipment assessed during this visit. Generally near term (<2 year payback) opportunities identified during this assessment may save 1.5% to 3% and the medium term (< 4 years payback) opportunities may save >3% natural gas savings. The long term (> 5 years) opportunities related to process changes etc. can result in substantially more savings (not estimated at this time).

These savings are based on “spot-check” of selected furnaces operating at the condition when the assessment was carried out. Estimate of savings should be considered as sample of possible savings. The plant personnel attending the assessment has shown willingness to use PHAST program and methodology to calculate savings for other equipment over a longer operating period. They are very keen on further analyzing and applying the necessary measures that can be economically justified.

A brief description of the selected saving opportunities is given below.

Short Term*

1. Reduce Oxygen in #8 boiler flue gases at high fire condition. During the visit the team measured 10% O2 in flue gases at 320 deg. F. (downstream of the air heater – just prior to exhaust gases leaving the boiler) while the boiler was fired at high fire condition. At high fire condition the boiler uses blast furnace gas and natural gas to deliver approximately 358 MM Btu/hr heat release from the burners. It is suggested that the plant consider adjusting the boiler burner air-fuel ratio and at the same time check any air leakage that may take place in the boiler with end result of 4% O2 in exhaust gases. This is realistic for gas fired boilers. With 320 deg. F. flue gas temperature and 4% o2 in flue gases, it is possible to save 2.8% fuel. Since the boiler is fired at full fire condition only for a few months, the total energy savings are calculated assuming 6 months or 4320 hours/year operation. Potential energy savings would be 44,000 MM Btu/year. Since the boiler is fired with mixed gases – natural gas and blast furnace gas, the gas cost is assumed to be $3.85 per MM Btu. Based on these numbers, it is estimated that reduction of O2 could save approximately $172,225 per year.
2. Reduce Oxygen in #8 boiler flue gases at low fire condition as stand-by. During the visit the team measured 10% O2 in flue gases at 300 deg. F. (downstream of the air heater – just prior to exhaust gases leaving the boiler). At low fire condition the boiler uses only natural gas to deliver approximately 15 MM Btu/hr heat release from the burners. It is suggested that the plant consider adjusting the boiler burner air-fuel ratio and at the same time check any air leakage that may take place in the boiler with end result of 4% O2 in exhaust gases. It may be necessary to adjust he ID fan speed to make sure that the negative pressure (draft) in the boiler is minimized to reduce any air leakage due to excessive negative pressure. The O2 reduction is realistic for gas fired boilers. With 300 deg. F. flue gas temperature and 4% o2 in flue gases, it is possible to save 2.62% fuel. Since the boiler is fired at low fire condition only for a few months, the total energy savings are calculated assuming 6 months or 4320 hours/year operation. Potential energy savings would be 1,998 MM Btu/year. Since the boiler is fired only with natural gas, the gas cost is assumed to be $8.00 per MM Btu. Based on these numbers, it is estimated that reduction of O2 could save approximately $13,588 per year.
3. Close openings for the Austenitizing furnace. The austenitizing furnace in the pipe mill is operated at 1580 deg. F. Flue gas analysis for this furnace showed that the burners are well tuned and excess air used for the burner gives about 4% O2 in flue gases. The furnace has small openings at the charge and discharge end of the furnace. We recommend that the plant consider a radiation shield or flexible curtain that would eliminate radiation heat losses from the furnace. The openings are relatively small but reducing radiation losses would offer reasonable savings. Based on assumption that the openings are 13 inch x 13 inch at charge and discharge end, and the furnace operates for 24 hrs x 360 days/year, use of a seal or curtain could save 440 MM Btu/year resulting in annual savings of $3,545 per opening or $7,090 per year.

Medium Term*

4. Reduce pilot gas use during stand-by operation for #8 boiler. We discussed operation of #8 boiler during stand-by condition. We were told that the stand-by operation requires fuel input of 15 MM Btu/hour to maintain the required steam pressure. The pilot burners are designed to use natural gas while the other burners can use blast furnace gas. We discussed possibility of reducing natural gas use in the pilots and use additional blast furnace gas to supply the necessary heat to maintain the required steam pressure. It was mentioned that the blast furnace valve needs to be completely closed to avoid uncontrolled flow of blast furnace gas. The group discussed possibility of providing a by-pass flow of blast furnace gas while the main valve was completely closed. The smaller by pass will allow better control of blast furnace gas to give necessary heat in the boiler. It is also necessary to redesign or install the natural gas pilot burner that will allow "turn-down" for the pilot natural gas. We assumed that it is possible to obtain 2 to 1 turn down for the boiler pilot burner and reduce natural gas flow from 15 MM Btu/hr to 7.5 MM Btu/hr during the stand-by condition. With 300 deg. F. flue gas temperature and reduction of gas flow to the boiler (7.5 MM Btu/hr) for 6 months operation (4320 hours/year) it is possible to save 32,400 MM Btu/year. Since this reduces natural gas use, the gas cost is assumed to be $8.00 per MM Btu. Based on these numbers, it is estimated that reduction of pilot natural gas flow could save approximately $259,200 per year.
5. Use of flue gas heat to preheat combustion air for four steel ladle heaters. The ladle heaters used to preheat ladles used for molten steel discharge flue gases at an average temperature of 2165 deg. F. Average firing rate for the ladles is 7.5 Mm Btu/hr. These ladle heaters operate for 8000 hours/year. The team measured flue gas analysis and found that at the time of measurement the flue gases contained zero oxygen and more than 2000 ppm of CO and combustibles. This indicated that there is very little air leakage and/or the burner air-fuel ratio is adjusted to minimize excess o2 in flue gases. Review of the originally installed system showed that the ladle heaters were equipped with recuperators to preheat combustion air and a few years ago these recuperators were removed. The team discussed possibility of reinstalling recuperators for the ladle heaters. Assuming average flue gas temperature of 2165 deg. F. and expected combustion air temperature of 1000 Deg. F. with burner adjusted to maintain 2% or in combustion products, it is possible to reduce fuel consumption by 34.6%. This would result in annual natural gas energy savings of 20,764 MM Btu/year. At natural gas cost of $8.00 per MM Btu and 8000 hours/year operation, expected annual savings for each ladle heart is $116,113. For four ladle heaters the savings would be approximately $664,452 per year.
6. Use of flue gas heat to preheat combustion air for Tube furnace in pipe mill. The tube reheating furnace in the pipe mill uses natural gas fired burners. We were informed that this continuous furnace has an average fuel consumption of 50 MM Btu/hour and operates for 8000 hours/year. We recommend that the plant verify and confirm actual gas flow for this furnace. Visit to the furnace showed that the original furnace design includes a recuperator and preheated combustion air system with insulated combustion air distribution and burners. However the recuperator is not being used at this time. Replacement or extensive repair of the recuperator to deliver preheated combustion air to the burners would result in substantial energy savings. With average flue gas temperature

of 1500 deg. F. and combustion air preheat temperature of 700 deg. F. F. while mainitng 4% O2 in flue gases, estimated fuel savings is 21.64%. Annual natural gas energy savings would be 86,540 MM Btu/year which represent savings of $692,300 per year.

Long Term*

7. Modify control system to allow air lead - gas follow control for #8 boiler to reduce possibility of smoke and added safety
8. Install proper control of air flow and gas flow for tundish preheaters and tundish dryers. All of these systems have constant air and variable or high-low gas flow control. This results in excess air and waste of fuel.
9. Install proper temperature indicator control panels for tundish preheaters and slab tundish dryer.
10. Evaluate feasibility of use of waste heat from reheat furnaces (after the recuperators) and tube furnace for 325 psig steam generation.
11. Consider heat recovery from boiler blow down water for #8 boiler.

Note that we could not collect sufficient data to analyze potential savings. The plant should collect appropriate data to analyze potential savings with implementation of these savings opportunities.

Management support and comments: The plant management is highly supportive of implementing the near and medium term opportunities with due considerations for the long-term opportunities. They are interested in learning more about energy saving opportunities for all energy user systems used in the plant and would send selected personnel for training, as these opportunities are made available in the near-by area.

Figure 2: Summary List of Recommendations

Near Term*

1. Reduce Oxygen in #8 boiler flue gases at high fire condition. .
2. Reduce Oxygen in #8 boiler flue gases at low fire condition as stand-by.
3. Close openings for the Austenitizing furnace

Medium Term*

4. Reduce pilot gas use during stand-by operation for #8 boiler.
5. Use of flue gas heat to preheat combustion air for **four** steel ladle heaters.
6. Use of flue gas heat to preheat combustion air for Tube furnace in pipe mill

Long Term*

7. Modify control system to allow air lead - gas follow control for #8 boiler to reduce possibility of smoke and added safety

8. Install proper control of air flow and gas flow for tundish preheaters and tundish dryers. All of these systems have constant air and variable or high-low gas flow control. This results in excess air and waste of fuel.
9. Install proper temperature indicator control panels for tundish preheaters and slab tundish dryer.
10. Evaluate feasibility of use of waste heat from reheat furnaces (after the recuperators) and tube furnace for 325 psig steam generation.
11. Consider heat recovery from boiler blow down water for #8 boiler.

Notes:

1. Definitions of the terms.
   - The near term opportunities include actions that could be taken as improvements in operating practices, maintenance of equipment or relatively low cost actions or equipment purchases.
   - The medium term opportunities would require purchase of additional equipment and/or changes in the system such as addition of recuperative air preheaters and use of energy to substitute current practices of steam use etc. It would be necessary to carryout further engineering and return on investment analysis.
   - The long term opportunities would require testing of new technology and confirmation of performance of these technologies under the plant operating conditions with economic justification to meet the corporate investment criteria.